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The association of sulcus vocalis and benign vocal cord lesions: intraoperative findings

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Abstract

Objective To investigate the presence of sulcus vocalis in patients who underwent phonomicrosurgery due to benign vocal cord lesions.

Methods Between January 2013 and June 2018, the records of 133 patients who underwent operations for benign vocal fold pathology were retrospectively reviewed. Intraoperative findings of the patients were noted. Patients were divided into two groups: patients with only benign vocal fold lesions (BVFL) and patients with benign vocal fold lesions and accompanying sulcus vocalis (SV + BVFL).

Results In total, 67 patients (50.4%; 38 females, 29 males) had BVFL and 66 (49.6%; 37 females, 29 males) had SV + BVFL. The patients in the SV + BVFL group were significantly younger than those in the BVFL group ($p = 0.039$). The sulcus was unilateral in 60.6% of the patients. The presence of sulcus vocalis was 49% and 47.6% in patients with a diagnosis of polyps ($n = 51$) and cysts ($n = 42$), respectively. A total of 12 of 13 patients with multiple benign vocal fold lesions had accompanying sulcus vocalis.

Conclusion Approximately half of the patients who underwent operations for benign vocal fold lesions had accompanying sulcus vocalis. More than half of the sulcus associated with benign lesions was unilateral.

Keywords Sulcus vocalis · Benign vocal fold lesions · Vocal polyp · Vocal cyst · Reinke's edema

Introduction

Sulcus vocalis can be defined as a full-thickness depression in the vocal fold epithelium. Three types of sulcus are recognized according to the classification of Ford et al. [1]. Type 1 sulcus, known as physiological sulcus, is considered to have no significant effect on voice quality, whereas type 2 sulcus (sulcus vergeture) and type 3 sulcus (true sulcus vocalis or pocket type) significantly affect voice quality. Type 2 and type 3 sulcus vocalis are also defined as "pathological sulcus". The most important feature that distinguishes type 1 sulcus from pathological sulcus is the absence of any evidence of loss or histopathological changes in the superficial lamina propria. The classification of pathological sulcus in itself is based on whether the sulcus configuration is linear (type 2) or focal (type 3). However, there are difficulties in classifying type 1 and type 2 sulcus vocalis without histopathological examination. The etiology of sulcus vocalis is unknown. However, in recent years, published cases of familial sulcus, sulcus vocalis in identical twins, and studies showing that the symptoms of sulcus patients started in childhood suggest that sulcus vocalis is a congenital problem [2–6]. Conversely, literature data also support the possibility that sulcus vocalis may be an acquired problem [7]. Previous studies have indicated an incidence of sulcus vocalis of between 0.4 and 48% [7–11].

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The diagnosis of sulcus vocalis is prone to various difficulties. Most benign vocal fold lesions can be easily detected by a videolaryngostroboscopic examination, whereas a depression of the sulcus epithelium in the vocal fold can be easily overlooked. In the presence of both sulcus vocalis and other benign vocal fold lesions, the sulcus may be more difficult to recognize.

Phonotrauma plays an important role in the formation of most benign vocal fold lesions. Functional voice problems can also lead to benign vocal fold lesions. Functional problems due to incomplete glottic closure and deterioration of vocal fold vibration quality in patients with sulcus vocalis also contribute to a worsening of already existing dysphonia. In particular, patients with unilateral sulcus or with asymmetrically located bilateral sulcus may experience formation of other benign vocal fold lesions due to the deterioration of vocal fold vibration symmetry.

A few studies and some case reports have reported an association between sulcus vocalis and other benign vocal fold lesions but these reports mostly show the association between vocal polyps and sulcus [12–19]. The aim of the present study was to investigate the presence of sulcus vocalis in patients undergoing phonomicrosurgery for benign vocal fold lesions and to determine the relationship between benign lesions and the sulcus.

Materials and methods

Between January 2013 and June 2018, the medical records of patients who underwent operations by the same surgeon (Senior Author A.V.S., the number of working years as an ENT specialist is 9) for benign vocal fold pathology were analyzed retrospectively. The study was approved by the local ethics committee of the Istanbul Training and Research Hospital. Information about preoperative videolaryngostroboscopic examinations, intraoperative examination findings, and age and gender information was collected for all patients. Patients who had a diagnosed benign vocal fold lesion confirmed by preoperative and intraoperative evaluation were included in the study. Patients with a history of endolaryngeal surgery or radiotherapy to the head and neck region and patients with pre-cancerous lesions or malignancy as a result of postoperative pathology were excluded from the study. Especially in the ipsilateral large lesions, light collapse regions between benign lesion and normal vocal fold epithelium were not evaluated as sulcus vocalis. Patients were divided into two groups: those with benign vocal fold lesions (BVFL group) and those with both benign vocal fold lesions and sulcus vocalis (SV + BVFL group). All patients underwent suspension laryngoscopy and endolaryngeal microsurgery. During the operation, both vocal folds were carefully palpated and examined by the right angle probe and curved alligator forceps. Submucosal infusion technique was used for some cases. In addition to examination of the benign vocal fold lesion, each patient was evaluated for the presence of sulcus vocalis, the type of sulcus vocalis, and the localization characteristics according to each benign vocal fold lesion. Case examples of benign vocal fold lesions accompanied by sulcus vocalis are shown in Figs. 1, 2, 3.

Statistical analysis

The descriptive statistics of the data included the mean, standard deviation, median lowest and highest, frequency, and ratio values. The distribution of variables was measured by the Kolmogorov–Smirnov test. The independent sample *t* test was used to analyze the quantitative independent data. The Chi-square test was used for the analysis of qualitative independent data. The Fischer exact test was used when the Chi-square test conditions were not met. The SPSS 22.0 program (SPSS, Inc., Chicago, Illinois, USA) was used in the analysis.

Results

A total of 133 patients were included in this study. Of these, 75 (56.4%) were female and 58 (43.6%) were male; 67 patients had BVFL (50.4%; 38 female, 29 male) and 66 had SV + BVFL (49.6%; 37 female, 29 male). No significant difference was noted in gender between the two groups ($p = 0.939$). The mean age of the patients with BVFL was 43.50 ± 12.7 years (range 22–69), and the mean age in the SV + BVFL group was 39.1 ± 11.7 years (range 14–64). The mean age of the SV + BVFL group was significantly lower

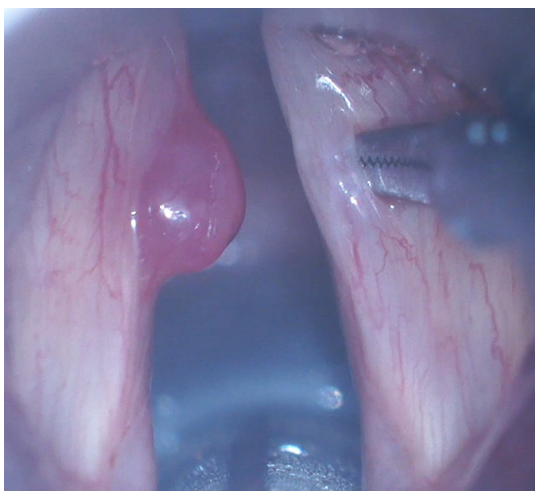

Fig. 1 Vocal polyp on the left and type 3 sulcus on the right vocal fold

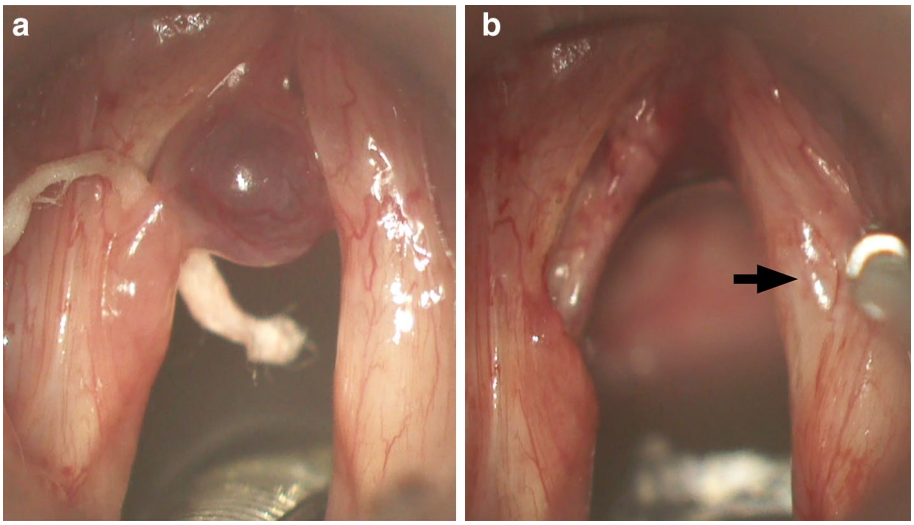

Fig. 2 **a** Vocal polyp and mucosal bridge on the left vocal fold. **b** Type 3 sulcus vocalis on the right vocal fold (arrow)

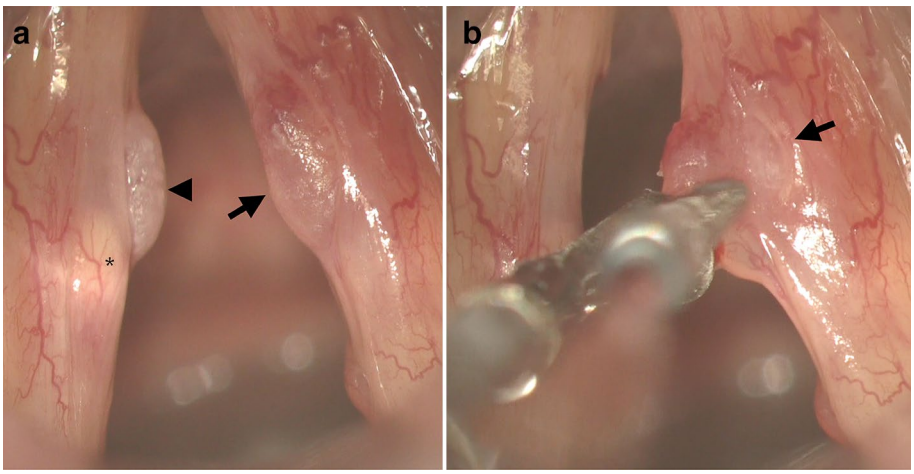

Fig. 3 **a** Left vocal cyst (asterisk), left vocal polyp (arrowhead), right vocal polyp (arrow). **b** Type 3 sulcus vocalis (arrow) on the right vocal fold just after the excision of the polyp on the left vocal fold

than that of BVFL group ($p = 0.039$) (Table 1). Distributions of all cases according to groups are shown in Table 1. The sulcus rates in association with other benign vocal fold lesions are shown in Fig. 4. The frequency of sulcus vocalis was 49% and 47.6% in patients with a diagnosis of polyp ($n = 51$) and cyst ($n = 42$), respectively. The rate of sulcus vocalis was 29.4% in patients with Reinke's edema. None of the five patients who underwent operations for vocal nodules had any sulcus vocalis, but 12 of the 13 patients with multiple benign vocal fold lesions had accompanying sulcus vocalis. In total, 60.6% of the patients with SV + BVFL had a unilateral sulcus (Table 2). The classification of sulcus vocalis was not possible in 8 cases. Of these 8 cases, 7 were similar to both type 1 and type 2 sulcus vocalis, in one case the sulcus configuration was similar to type 3, and depth was similar to type 1 sulcus vocalis. For these reasons, these 8 cases were classified as unknown in Table 2. In 16 of the patients with a benign vocal fold lesion and a unilateral sulcus, the sulcus was located in the same vocal fold as the benign lesion. In 20 patients, the sulcus was located in the opposite vocal fold. The localization characteristics and types of sulci are shown in Table 3.

Discussion

Sulcus vocalis can be easily overlooked by routine examination methods, whereas it can sometimes be diagnosed during direct laryngoscopy [20]. The accompanying sulcus can be readily recognized by careful palpation of the entire vocal fold epithelium in patients undergoing operations for benign vocal fold lesions. Selleck et al. found that sulcus vocalis prevalence was 31% in dysphonic patient population evaluated by VLS [21]. In the current study in which we evaluated intraoperative findings, higher sulcus ratio may be due to the diagnosis of some sulcus cases only during direct laryngoscopy.

Table 1 Distributions of all cases according to groups

	BVFL ($n=67$)			SV + BVFL ($n=66$)			p
	Mean ± SD/n-%		Median	Mean ± SD/n-%		Median	
Age	43.5 ± 12.7		43.0	39.1 ± 11.7		39.0	*0.039*[t]
Age							
≤ 40 years	28	41.8%		35	53.0%		0.194[X²]
> 40 years	39	58.2%		31	47.0%		
Gender							
Female	38	56.7%		37	56.1%		0.939[X²]
Male	29	43.3%		29	43.9%		
Benign lesions polyp ($n=51$)	26/67	38.8%		25/66	37.9%		0.931[X²]
Cyst ($n=42$)	22/67	32.8%		20/66	30.3%		0.794[X²]
Reinke's Edema ($n=17$)	12/67	17.9%		5/66	15.2%		0.095[X²]
Keratosis ($n=2$)	0	0.0%		2/66	7.6%		0.154[X²]
Pseudocyst ($n=2$)	1/67	1.5%		1/66	1.5%		0.991[X²]
Fibrous mass ($n=1$)	0	0.0%		1/66	1.5%		0.313[X²]
Nodule ($n=5$)	5/67	7.5%		0	0.0%		*0.026*[X²]
Multiple benign lesions ($n=13$)	1/67	1.5%		12/66	18.2%		*0.002*[X²]
Polyp and cyst	1			1			
Polyp and mucosal bridge	0			2			
Polyp and pseudocyst	0			1			
Polyp and Reinke's edema	0			1			
Reinke's edema and keratosis	0			2			
Reinke's edema and pseudocyst	0			1			
Cyst and pseudocyst	0			1			
Cyst and keratosis	0			1			
Cyst and mucosal bridge	0			1			
Cyst and Reinke's edema	0			1			
Reactive lesion	4/67	6.0%		5/66	7.6%		0.712[X²]

Statistically significant p values are in italics ($p < 0.05$)

BVFL benign vocal fold lesions, *SV + BVFL* sulcus vocalis + benign vocal fold lesions

[t] t test/[X²] Chi-square test (Fischer test)

Sulcus affects the vocal fold vibration characteristics. As we know from the works of Titze, asymmetric forces play a role in vocal fold vibrations [22]. Asymmetric forces that produce vocal cord vibration can lead to microtrauma in the superior and inferior of the sulcus. Phonotrauma, which has an important role in the etiology of benign vocal fold lesions, may facilitate the formation of these lesions in the presence of vocal fold sulci. Two possible underlying mechanisms can be proposed. The first is that the mucosal wave starts from the subglottic region and strikes a relatively stiffer structure in the sulcus, resulting in chronic trauma, edema, and micro bleeding in the superficial layer of the lamina propria. The second mechanism is the formation of similar chronic trauma, edema, and micro bleeding in the superficial layer of the lamina propria of the opposite vocal fold. The second view may be valid for sulcus vocalis with bilateral asymmetric localization but not for sulcus with symmetric localization. In our study, more than a half of the accompanying sulcus vocalis was unilateral. In patients with unilateral sulcus vocalis, vocal fold vibration symmetricity is more affected than bilateral sulcus. Therefore, unilateral sulcus may be more likely to cause benign vocal cord lesions than bilateral sulcus.

Some studies reported in the literature have shown an association between vocal polyps and sulcus vocalis; however, no comprehensive studies have yet demonstrated an association between other benign vocal fold lesions and sulcus vocalis. Carmel-Neiderman et al. found an accompanying sulcus vocalis in 14 (15.7%) of 89 patients who underwent operations for vocal fold polyps [18]. In that study, all the sulci were unilateral and 79% had an ipsilateral localization. Another study that examined the association between

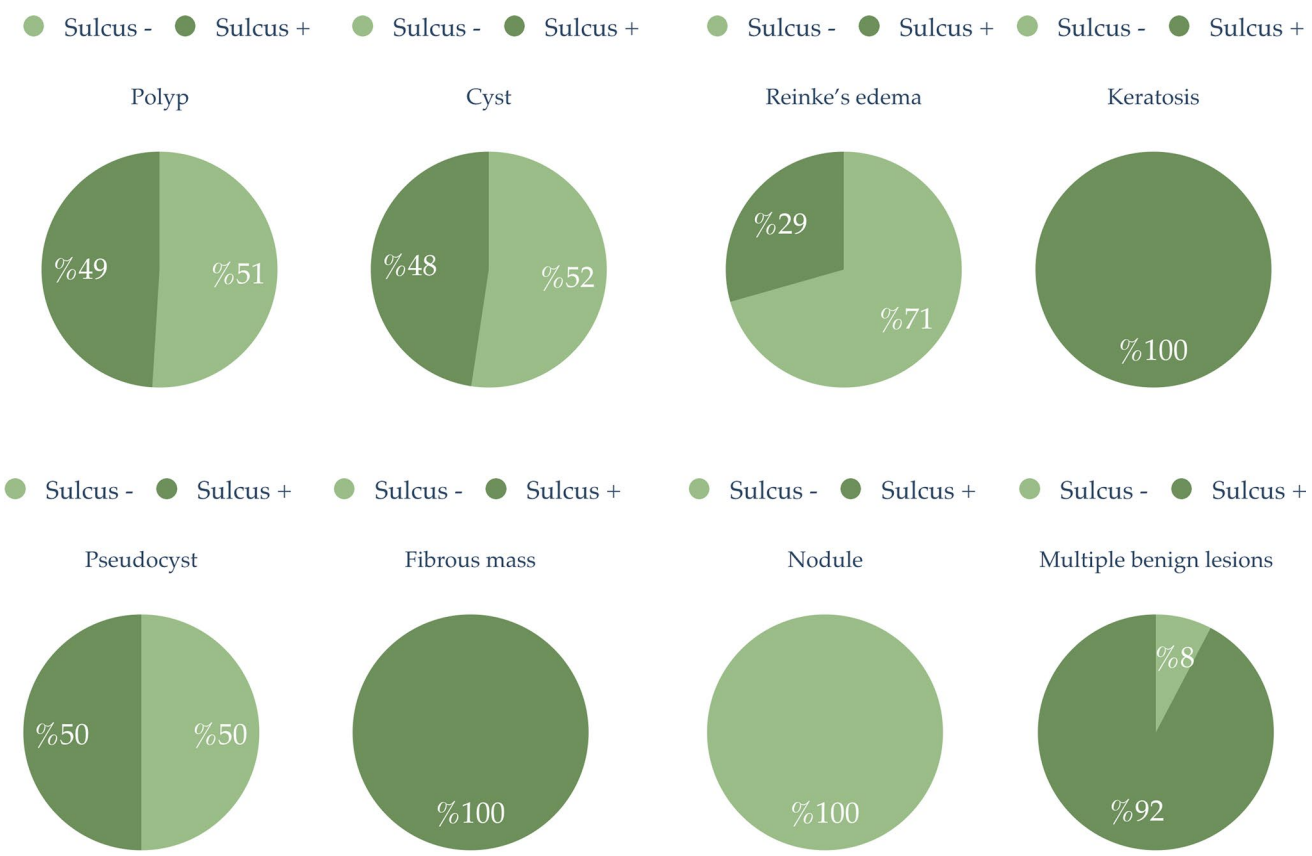

Fig. 4 Sulcus rates in benign vocal fold lesions

Table 2 Localization characteristics of the sulcus and distribution of the cases according to the sulcus types

		n	%
Sulcus vocalis	(−)	67	50.4
	(+)	66	49.6
Localization of sulcus	Unilateral	40	60.6
	Bilateral	26	39.4
Type of sulcus[a]	Type I	5/66	7.6
	Type II	18/66	27.3
	Type III	35/66	53.0
	Unknown	8/66	12.1

[a]According to classification of Ford et al. [1]

vocal polyps and sulcus reported an incidence of coexisting vocal polyp and sulcus of 6.4% (18/280) and an incidence of unilateral sulcus of 83.3% [12]. Eckley et al. found a ratio of 25.9% for accompanying sulcus in patients undergoing operations for vocal polyps [15]. In the current study, the association of vocal polyps and sulcus was higher (49%) than the association reported in the other studies in the literature. The reason for this difference may be methodological differences (e.g., individual assessment differences) between the studies and may reflect the possibility that sulcus vocalis may occur at different frequencies in different populations.

Martins et al. found that a rate of coexistence of 23% for sulcus vocalis in vocal fold cysts [19]. In our study, this rate was 47.6%, which was similar to the rate for polyps. This rate was significantly lower for Reinke's edema (29.4%). Bilateral vocal nodules, which were closely associated with phonotrauma and misuse of voice, did not show any coexistence with sulcus vocalis. This finding is not surprising, because the localization of sulcus vocalis is similar to the classical localization of the vocal nodules. The sulcus is located on the medial side of the vocal fold, and the maximum trauma forms around the sulcus, not at the point of the sulcus. Therefore, bilateral vocal fold nodules are not expected to develop in patients with sulcus vocalis.

Almost all patients with more than one benign vocal fold pathology may have an association with sulcus vocalis due to the abnormal and asymmetric vibration of the vocal folds. Because of this high rate, the possibility of coexistence of sulcus vocalis in patients with combined vocal fold lesions should be kept in mind, and these possibilities should be shared with the patient in the preoperative period. Byeon et al. reported a high recurrence rate in patients with both polyps and sulcus [12]. Therefore, a higher probability of

Table 3 Detailed localization characteristics of the SV + BVFL group

Lesions	Localization of the sulcus				Total
	Unilateral		Total	Bilateral	
	Ipsilateral	Contralateral			
Polyp	6	9	15 (60%)	10 (40%)	25
Cyst	8	7	15 (75%)	5 (25%)	20
Reinke's edema (bilateral)[a]	–	–	2 (40%)	3 (60%)	5
Pseudocyst	0	1	1 (100%)	0 (0%)	1
Keratosis (bilateral)[a]	–	–	1 (50%)	1 (50%)	2
Fibrous mass	1	0	1 (100%)	0 (0%)	1
Polyp and cyst[a]	–	–	1 (100%)	0 (0%)	1
Polyp and mucosal bridge	0	2	2 (100%)	0 (0%)	2
Polyp and pseudocyst	0	0	0 (0%)	1 (100%)	1
Polyp and Reinke's edema	0	0	0 (0%)	1 (100%)	1
Reinke's edema and keratosis	0	0	0 (0%)	2 (100%)	2
Reinke's edema and pseudocyst	0	0	0 (0%)	1 (100%)	1
Cyst and pseudocyst	1	0	1 (100%)	0 (0%)	1
Cyst and keratosis	0	0	0 (0%)	1 (100%)	1
Cyst and mucosal bridge	0	1	1 (100%)	0 (0%)	1
Cyst and Reinke's edema	0	0	0 (0%)	1 (100%)	1
	16	20	40 (60.7%)	26 (39.3%)	66

[a]Because the benign lesions in these patients were located bilaterally, the localization information for the unilateral sulcus vocalis was not reported

recurrence should be considered in these patients, although no study has yet demonstrated the possibility of recurrence of other benign vocal fold lesions that coexist with sulcus vocalis [18]. Treatment of benign vocal fold lesions that are accompanied by sulcus may also produce less satisfactory results than is obtained for treatment of lesions not accompanied by a sulcus.

Another controversial issue is whether to intervene in treating the sulcus vocalis when it is accompanied by benign lesions. Based on our own clinical experience, we recommend not intervening in the sulcus when it is recognized during surgery, because most patients desire to regain their previous voice they had prior to the occurrence of the coexisting benign vocal fold lesion. In addition, an intervention such as a sulcusectomy may result in more significant problems, especially in the postoperative period, as it may result in scarring in a deeply penetrating sulcus. The high risk of vocal cord scarring caused by intervention in the sulcus, which was detected during the operation, is entirely based on our clinical observations. Further studies are needed to determine the optimum strategy for treating this situation.

Byeon et al. reported a mean age of 42.3 in their patients with vocal polyps and 46.5 in their patients with sulcus and vocal polyps [12]. In the current study, the mean age was significantly lower for the patients with both sulcus vocalis and another benign vocal fold lesion than for the patients without sulcus. This suggests that possible cases with congenital sulcus may have an earlier mean age of occurrence due to benign vocal fold lesions arising from phonotrauma. Previous studies have found that sulcus is more common in men; however, in the current study, the ratio of sulcus vocalis showed no significant difference between genders [9, 23]. Further studies are needed for evaluation of the gender effect on sulcus vocalis that accompanies benign lesions.

Conclusion

Sulcus vocalis may be an accompanying condition in about half of the patients undergoing operations for benign vocal fold lesions. In these cases, more than half of the accompanying sulcus is unilateral. The very high possibility of the coexistence of sulcus vocalis in patients with multiple benign vocal fold lesions should therefore be kept in mind.

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Compliance with ethical standards

Conflict of interest The authors declares that there is no conflict of interest.

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